3-28-2014

Observing Argon Clusters in a Conical Expansion

Gregory Adams
Indiana University - Purdue University Fort Wayne

Aaron Magner
Indiana University - Purdue University Fort Wayne

Observing Argon Clusters in a Conical Expansion

Gregory Adams; Aaron Magner; Mark Masters, Phd
Department of Physics, Indiana University-Purdue University-Fort Wayne

Abstract

Argon clusters are large molecules which can form in gas jets, however they are very unstable molecules because they are held together only by weak electrostatic forces. Clusters have been used in nonlinear optics, chemical reactions, x-ray generation, and as a target for high power lasers. (DeArmond et al. 2008) We are interested in finding the parameters that determine the mean cluster size. Due to the instability of these molecules, we must use non-destructive techniques to measure the mean cluster size. One such method is measuring Rayleigh scattered light from a laser passing through the jet. The second method is using interferometry to measure the index of refraction of the clusters. Using these measurements it is possible to estimate the mean cluster size.

Background

Clusters or Van-der-Waals molecules form in a process called nucleaction, in which atoms or molecules collide and stick. The interatomic bonds are forces arising from slight polarization of the atoms. The result is that while large numbers of atoms can form a single cluster, the cluster remains unstable and may evaporate as a result of a collision with as few as one atom.

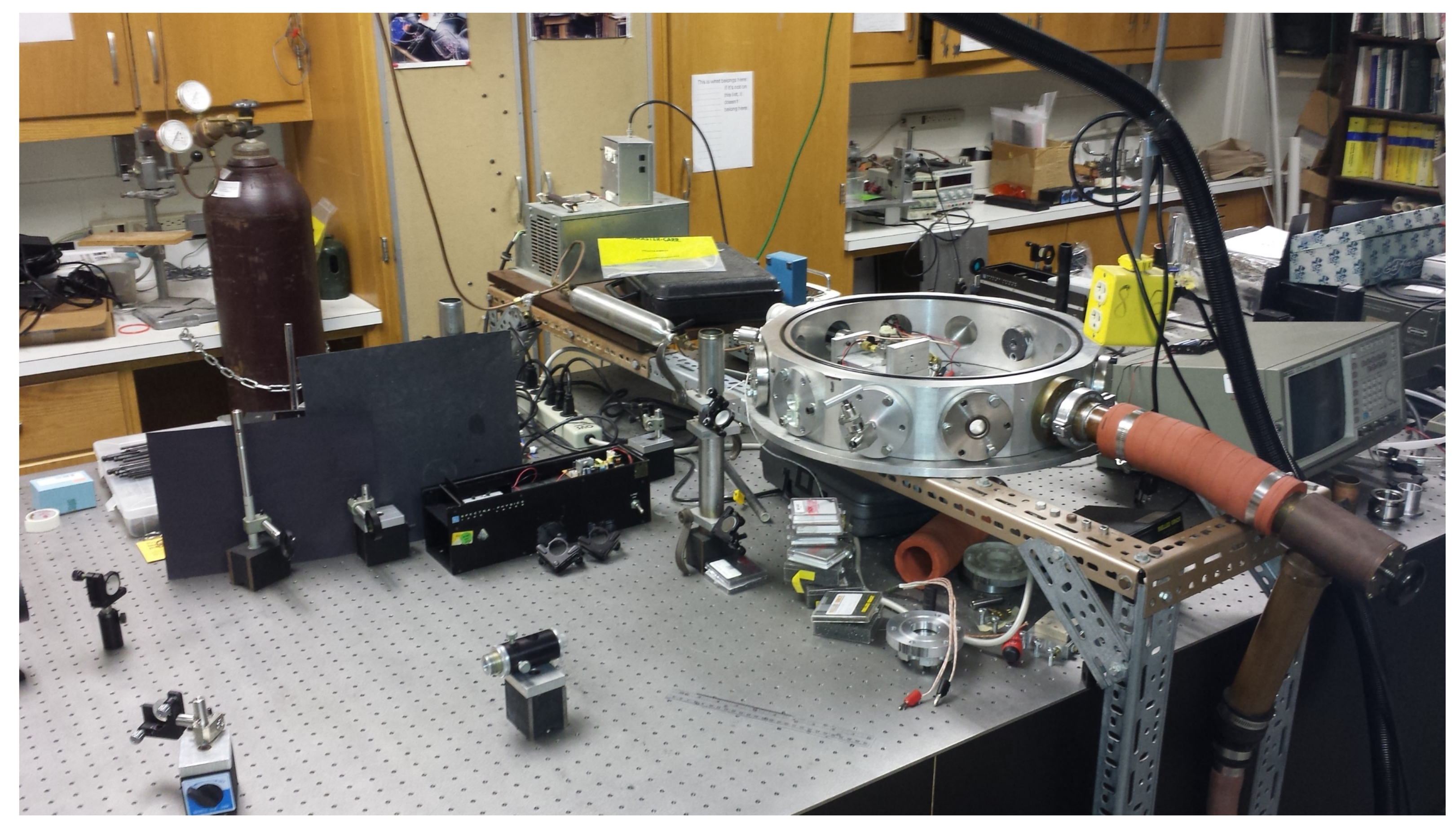
Clusters form in many natural and man-made environments. Examples include atmospheric aerosols, rocket thruster plumes, and gas jets in vacuum. They are also very useful in research applications such as X-ray production and creating very short laser pulses.

There are a number of theoretical models for cluster formation and growth. These models are based either on thermodynamics or kinetics. (Sun Q. & Boyd I. 2005) However there is a lack of experimental evidence to support the use of either approach over the other. In order to use clusters it is important to be able to predict their size. And in practice many assumptions have to be made to model cluster formation. Therefore there is a need for experimentation examining the relation between cluster formation and growth and the many quantities which govern that process.

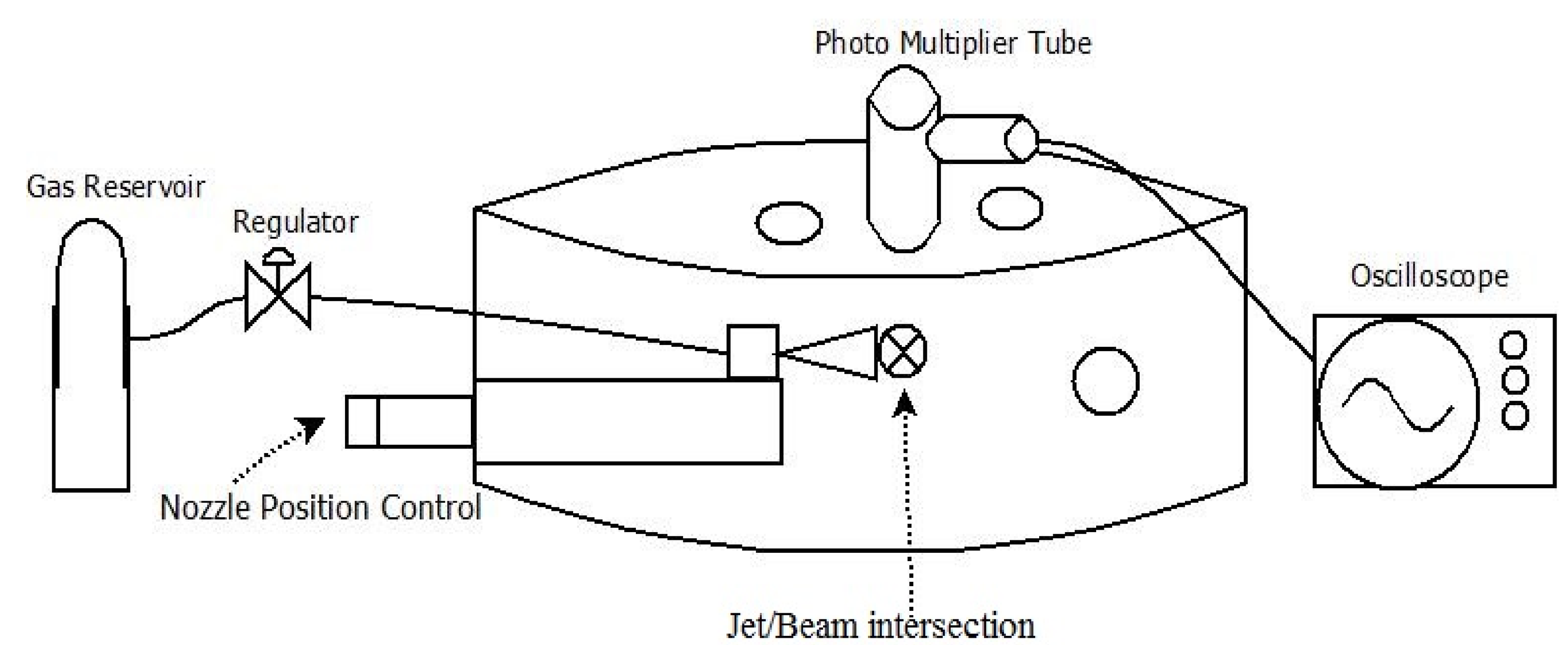
Our Approach

Measuring cluster size is made difficult by their fragility. In the past a number of direct methods have been used, but they tend to be destructive. Our solution to this is to use Rayleigh scattered light to estimate the mean cluster size. Using interferometry with Rayleigh scattering we hope to accurately measure the mean cluster size and the number per volume.

Our Set Up



Picture of Experiment

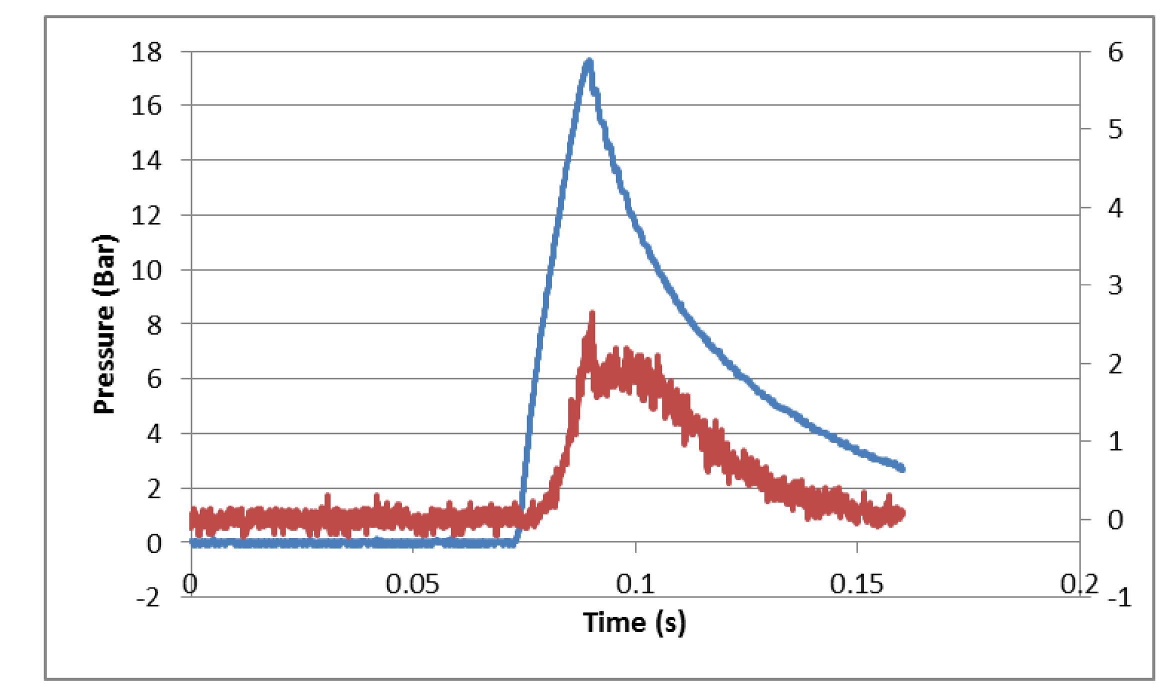


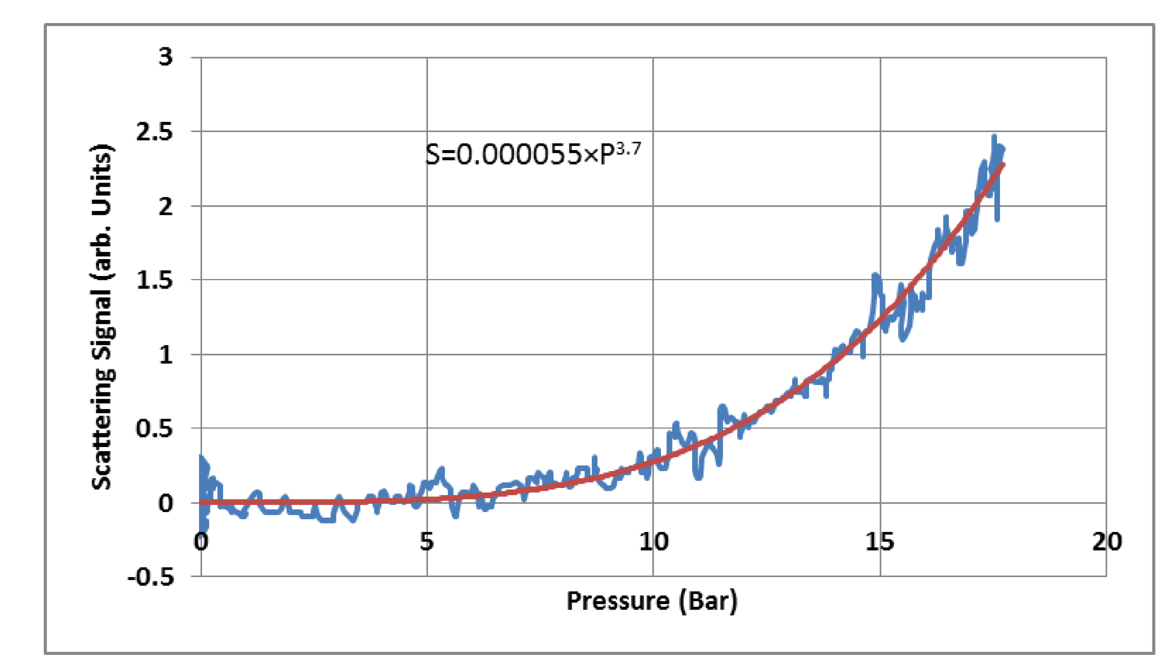
Schematic of Experiment

Procedure

The chamber is pumped to near vacuum pressure (20 mbar). The circular nozzle is opened for 10 ms producing a spherical jet which passes through the beam of a 532 nm LASER. Laser power was measured to be 8.6 mW +/-0.5 mW. Because Rayleigh scattering is most intense perpendicular to the polarization of the incident light, the beam is horizontally polarized and the detector is placed directly above the intersection. Interferometry can be used to determine the index of refraction of the clusters. We hope to obtain that data with Rayleigh scattering data in the future.

Some Previous Results





Our Goals

We want to relate the cluster size to the source pressure and the temperature of the nozzle. The models and our previous results suggest that those quantities are important in cluster formation and growth. We will also examine how the clusters change over time by varying the position of the nozzle in relation to the beam.